Rebuttal of Reports Prepared by:

James W. Embree, Ph.D., DABT
Susan M. Gallardo, P.E.

February 2008

Prepared for:

Ecological Rights Foundation
867 B Redwood Drive
Garberville, CA 95542

Humboldt Baykeeper
217 E Street
Eureka, CA 95501

Prepared by:

Atul M. Salhotra, Ph.D.
Principal Professional

Risk Assessment & Management Group, Inc.
5433 Westheimer Road, Suite 725
Houston, TX 77056
Tel: (713) 784-5151
Fax: (713) 784-6105
Email: Asalhotra@ramgp.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1.1 Introduction

This report, along with the figures, tables and photos contained herein may be used as exhibits.

I have been retained by Humboldt Baykeeper and Ecological Rights Foundation to prepare this Expert Report in response to Expert Report of James W. Embree, Ph.D., DABT, January 28, 2008, and the Expert Witness Report of Susan M. Gallardo, PE, January 29, 2008.

In order to perform this evaluation I reviewed the above reports as well as the reports and documents presented in my January 2008 *Preliminary Human Health Risk Assessment, Former Railroad Yard in City of Eureka, Humboldt County, California.* A list of additional documents that have been provided to me after submission of my Expert Report and/or were used in the preparation of this report is attached hereto.

My qualifications, along with a list of my publications from the past ten years, a list of my testimony at deposition and trial during the last four years, and compensation are contained in my Expert Report (RAM 2008) and in my curriculum vitae attached as Appendix C to that Report.

1.2 Background

In his report (Geomatrix January 28, 2008), Dr. Embree expresses his opinion that "site conditions do not present an imminent and substantial endangerment". His assertion is based on the following four opinions:

Opinion 1: Chemical concentrations have been mitigated through limited soil removal and use of pea gravel to control contaminated material,

Opinion 2: Access to the site is controlled and limited,

Opinion 3: Health Risk Assessment (HRA) indicates insignificant risk due to residual levels, and

Opinion 4: Site is under the direct supervision of the California Regional Water Quality Control Board.

Based on a review of the data, I address each of the four above opinions, three of these topics are also discussed in my January 2008 report, Preliminary Human Health Risk Assessment Former Railroad Yard in City of Eureka, Humboldt County, California (RAM 2008).

1.3 Limited Soil Removal and Use of Pea Gravel to Control Contaminated Material

Although some soil has been removed from the site per Geomatrix (2002 and 2003), the removal action was limited to two areas that showed the highest exceedences of lead and copper. Due, in part, to the inadequacies of the site assessment, additional areas remain on site where residual chemicals, including arsenic, dioxins, furans and PCBs, are found above human health screening levels. Further, no removal action has been taken for PCBs, dioxins and furans, (or for other potentially relevant chemicals) which have been detected in sediments at the site at levels that exceed human health screening values.

As discussed in RAM 2008, dioxins, furans, PCBs and other hazardous chemicals in the sediments on site and at the discharge locations are likely transported to Clark Slough and the Bay by surface runoff and groundwater and are available to bioaccumulate in the food chain. Fish tissue samples collected from Clark Slough by HT Harvey and Associates on January 10, 2008 (Test America 2008) were analyzed for dioxins and furans. (I have been informed they are also being analyzed for PCBs.) The analytical lab results confirm that dioxins and furans are accumulating in the food chain in Clark Slough. Two species of Sculpin were analyzed. A sample of Staghorn sculpin (*Leptocottus armatus*) was found to have a dioxins/furans TEQ level of 4.288 picograms per gram (pg/g, parts per trillion - ppt). A sample of Prickly sculpin (*Cottus asper*) was found to have a dioxins/furans TEQ level of 2.635 pg/g (ppt). Both of these samples exceed relevant human health screening levels. For example, the United States Environmental Protection Agency recommends "no consumption" of fish tissue with dioxins/furans TEQ concentrations of 1.2 pg/g or greater (USEPA, 1999). The USEPA notes that dioxins and furans are associated with a wide array of adverse health effects in experimental animals, including toxic effects to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system. Dioxins are also classified by the USEPA as probable human carcinogens. If dioxin-like PCBs are also present in these fish tissues, that would increase the TEQ and cumulative risk from these chemicals. Clark Slough is habitat for additional edible species of fish and shellfish such as dungeness crab and starry flounder. Species in higher trophic levels that feed on biota from Clark Slough, including predatory fish that might be consumed by humans, would be expected to have even higher levels of dioxins/furans.

The evidence of bioaccumulation of these highly toxic chemicals in Clark Slough, in combination with the evidence of continuing soil and sediment contamination, indicates that the limited soil removal actions at the site to date have not removed the significant threat to human health. It should also be noted that the USEPA, at the suggestion of the California State Water Resources Control Board (SWRCB), has recently listed Humboldt Bay as "impaired" for dioxins based on evidence of bioaccumulation in the food chain (SWRCB 2007). The listing was based on concentration of dioxins in fourteen samples of fish (including sculpin), and shellfish, that exceed the California Office of Environmental Health Hazard Assessment (OEHHA) screening value of 0.3 ppt. Not only do the Clark

Slough sculpin samples greatly exceed that screening value, their levels are higher than all but one of the fourteen samples relied on for the listing.

Based on the above, the limited removal activities and use of pea gravel has not eliminated the imminent and substantial risk of harm to human health.

1.4 Access to Site

Although the site is fenced, it appears the site is still accessible to trespassers as is evident from photographs taken in July 2007 and January 2008 attached to RAM (2008). Dr. Embree failed to note that the site is zoned for public use, and hence access will not be limited in the future. Potential future uses of the site could include publicly accessible areas such as parklands, wetland preserves, or other public uses that could result in contact with contaminated soils, water or sediments. It is my understanding that a proposed development project for the site includes a wetlands preserve in an area of the site where unacceptable levels of dioxins and furans are present in sediments. Dr. Embree's opinions do not take into consideration the potential exposures to these highly toxic substances. Further, the mere covering of impacted areas with gravel will not prevent exposures under reasonable future development and land use conditions.

Based on the above, the fence has not eliminated the current or potential future human health risk.

1.5 Health Risk Assessment (HRA)

The HRA (Geomatrix, 1997) and its addendum (Geomatrix, 2000) are inadequate for a variety of reasons; and therefore, opinions based on the risk assessment are not valid and cannot be substantiated. A few of the reasons are presented below:

1.5.1 Selection of Chemicals of Concern

The HRA and its addendum focused only on a selected set of chemicals typically representative of a hydrocarbon contaminated site. As discussed in Section 3.0 of RAM (2008) and Sections 1.3 and 2.2 of this report, several chemicals of concern were not included. Without analysis that includes all the relevant COCs, the HRA and its addendum cannot be relied upon to conclude that the site does not present an imminent and substantial endangerment to human health and the environment. Had these chemicals been included, the cumulative risk would have been higher and possibly unacceptable.

1.5.2 Issues Related to the Detection Limit

Background site information has indicated the presence of USTs containing leaded gasoline. Leaded gasoline typically includes 1,2-Dichloroethane (EDC) and 1,2-Dibromoethane (EDB) as anti knock additives. These chemicals have carcinogenic and non-carcinogenic health effects on humans. The following table shows the carcinogenic (slope factor) and non-carcinogenic (reference dose) toxicity values of EDC and EDB. The toxicity values of benzene are also included in the table for comparison. As an example, EDB is 37 (2/0.055) times more toxic as a carcinogen than benzene by the oral route of exposure.

Chemical of Concern	RfD_o	RfD_i	SF_o	SF_i	Source
EDC - 1,2- Dichloroethane	0.02	0.0014	0.091	0.091	Region 9 USEPA PRG table Oct 2004
	0.03	-	0.047	0.073	CHHSL Jan 2005
EDB - 1,2- Dibromoethane	0.009	0.0026	2	2	Region 9 USEPA PRG table Oct 2004
Benzene	0.004	0.0086	0.055	0.027	Region 9 USEPA PRG table Oct 2004
	0.003	0.0171	0.1	0.1	CHHSL Jan 2005

RfD – Reference dose in mg/kg-d; SF – Slope Factor in $(mg/kg\text{-}d)^{-1}$
$_o$ – Oral exposure pathway, $_i$ Inhalation exposure pathway
PRG – USEPA Region 9 Preliminary Remediation Goals
CHHSL – California Human Health Screening Levels

The following table lists the screening levels of EDB and EDC in soil, air, and tap water as listed by USEPA Region 9 and CHHSL.

Chemical of Concern	USEPA Region 9 PRG				CHHSL		MCL ug/l
	Soil (mg/kg)		Ambient Air (ug/m^3)	Tap Water (ug/l)	Indoor Air (ug/m^3)		
	Residential	Industrial			Residential	Industrial	
EDC - 1,2-Dichloroethane	0.28	0.6	0.074	0.12	0.116	0.195	0.5
EDB - 1,2-Dibromoethane	0.032	0.073	0.0034	0.0056	NA	NA	0.05

At the site, EDC was only analyzed in groundwater once and reported as non-detectable at the detection limit of 0.5 ug/l. This detection limit is 4 times the standard for USEPA Region 9 tap water. Further, groundwater has not been analyzed for EDB at all. An alternate method with lower detection limits should have been used to confirm the presence or absence of these chemicals.

1.5.3 Calculation of 95% Upper Confidence Limit (UCL) of the Mean

The specific method used to estimate the 95% UCL of the mean is not described in Geomatrix (1997). Due to the presence of large proportion of concentrations reported as non-detect (ND) values, the estimated 95% UCL may not be accurate. It appears that all the ND values were used to estimate the 95% UCL. For a large site, this may not be reasonable as the use of ND values (especially those located on the periphery of the impacted areas) would “dilute” the calculated (95% UCL) concentrations. The 95% UCL should be calculated separately for the sources (most impacted areas) to adequately determine the exposure to such areas. This is a significant flaw in the existing risk analysis and, absent such analysis, it is my opinion that the HRA and its addendum cannot be relied on to make conclusions regarding health risks at the site.

1.5.4 Missing Exposure Pathways

The HRA assessment and its addendum neglected several complete exposure pathways. Examples include dermal contact with water by a construction worker, contact with sediments, and ingestion of fish and other marine organisms. See Sections 6.0 and 7.0 of RAM (2008).

The HRA and its addendum did not consider the potential future use of groundwater. It is likely that groundwater could be used for drinking water, irrigation, or other uses. No discussion of the suitability of drinking water (based on TDS or yield) or the risk from consumption was presented. While I agree with Mr. Embree that groundwater contamination levels can be compared to screening level Preliminary Remediation Goals (USEPA PRGs), I disagree with his conclusions on that matter. The site’s groundwater impacts have been insufficiently characterized, and the limited sampling that has been performed demonstrates that human health screening values have been exceeded in almost all the site’s monitoring wells. Further, the potential migration of groundwater and dissolved contaminants to Clark Slough and ultimately to Humboldt Bay has not been considered.

Fish tissue samples collected from Clark Slough by HT Harvey and Associates on January 10, 2008 were analyzed for dioxins and furans. (I have been informed they are also being analyzed for PCBs.) The analytical lab results confirm that dioxins and furans are accumulating in the food chain in Clark Slough. Two species of Sculpin were analyzed. A sample of Staghorn sculpin (*Leptocottus armatus*) was found to have a dioxins/furans TEQ level of 4.288 pg/g (ppt). A sample of Prickly sculpin (*Cottus asper*) was found to have a dioxins/furans TEQ level of 2.635 pg/g (ppt). Both of these samples exceed relevant human health screening levels. For example, the United States Environmental Protection Agency recommends “no consumption” of fish tissue with dioxins/furans TEQ concentrations of 1.2 pg/g or greater. The USEPA notes that dioxins and furans are associated with a wide array of adverse health effects in experimental animals, including toxic effects to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system. Dioxins are also classified by the USEPA as probable human carcinogens. If dioxin-like PCBs are also present in these fish tissues, that would increase the TEQ and cumulative risk from these chemicals. Clark Slough is habitat for additional edible species of fish and shellfish such as dungeness crab and starry flounder. Species in higher trophic levels that feed on biota from Clark Slough, including predatory fish that might be consumed by humans, would be expected to have even higher levels of dioxins/furans.

The evidence of bioaccumulation of these highly toxic chemicals in Clark Slough, in combination with the evidence of continuing soil and sediment contamination, indicates that the limited soil removal actions at the site to date have not removed the significant threat to human health. It should also be noted that the USEPA, at the suggestion of the SWRCB, has recently listed Humboldt Bay as "impaired" for dioxins based on evidence of bioaccumulation in the food chain. The listing was based on concentration of dioxins in fourteen samples of fish (including sculpin), and shellfish, that exceed the OEHHA screening value of 0.3 ppt. Not only do the Clark Slough sculpin samples greatly exceed that screening value, their levels are higher than all but one of the fourteen samples relied on for the listing.

Consideration of these exposure pathways would increase the cumulative risk. Having not analyzed all the exposure pathways and reliance on the HRA and its addendum is insufficient. As an additional example, potential risk of cancer due to ingestion of arsenic in Clark Slough fish is presented in Appendix A.

1.5.5 Updates to Toxicity Value

Since the publication of the addendum to the human health risk assessment report by Geomatrix Consultants in April 2000, USEPA and CAL EPA have changed several toxicity values of chemicals. Tables 1 and 2 (attached) show the resulting changes in non-carcinogenic and carcinogenic risk, respectively, due to the changes in toxicity. A few examples of updated toxicity values include:

- Arsenic –The inhalation reference dose for arsenic has been updated to $8.57x10^{-6}$ mg/kg-d. This increases the non-carcinogenic risk by a factor of 2.6. Also, the oral slope factor toxicity value has been increased to 9.45 $(mg/kg\text{-}d)^{-1}$. This increases the carcinogenic risk by a factor of 5.

- Cadmium – Since 2000, an oral slope factor value of 0.38 $(mg/kg\text{-}d)^{-1}$ has been added to cadmium. Further, CHHSL guide reports the inhalation reference dose for cadmium as $5.71x10^{-6}$ mg/kg-d. These updates increase the non-carcinogenic risk by a factor of 4.15 and the carcinogenic risk by a factor of 1.6

- Beryllium – The inhalation reference dose for beryllium has been updated to $2x10^{-6}$ mg/kg-d and this increases the non carcinogenic risk by a factor of 2.5. Similarly, mercury's inhalation reference dose has been updated to $2.6x10^{-5}$ mg/kg-d, thereby increasing the non-carcinogenic risk by a factor of 1.6.

- Cobalt – Updates of the inhalation and oral reference dose of cobalt in the CHHSL guide result in an increased non-carcinogenic risk. The hazard index increases by a factor of 4,154.

- Non-carcinogenic risk for other metals like antimony, copper, silver and zinc decrease due to the new updated toxicity values.

- Naphthalene – In 2000, when the risk assessment addendum was conducted, naphthalene was not considered to be a human carcinogen. Since 2002, naphthalene has been identified as a human carcinogen and has an oral and inhalation slope factor of 0.12 $(mg/kg\text{-}d)^{-1}$. Inhalation reference dose for naphthalene has also been updated to 0.00257 mg/kg-d in CHHSL guide compared to the inhalation reference dose of 0.00086 mg/kg-d in 2000. These changes increase the carcinogenic risk and decrease the non-carcinogenic risk.

- Carcinogenic chemicals of concern - benzo(a)anthracene, benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene have an increased inhalation slope factor of 0.73 mg/kg-d from 0.39 mg/kg-d and for benzo(a)pyrene the inhalation slope factor has been increased from 3.9 to 7.3 mg/kg-d. These changes reduce carcinogenic risk.

Based on the above deficiencies in the HRA and its addendum, the estimated health risk is not representative of the current and future conditions.

1.6 Supervision by RWQCB

The mere fact that the site is under the supervision of the RWQCB does not imply or ensure the absence of substantial risk. In fact, most known contaminated sites, including toxic superfund sites, are regulated by one or more governmental agencies. Further, it is not clear whether the above-mentioned deficiencies in the HRA and its addendum are known or have been discussed with RWQCB.

1.7 Overall Conclusion

None of Dr. Embree's four opinions are scientifically valid arguments to support his conclusion that there does not exist an imminent and substantial endangerment to human health at the Site.

2.1 Background

Ms. Gallardo presents the following opinions:

Opinion 1. Sites where soil and groundwater are affected by petroleum hydrocarbons and metals are common, and the Balloon Track is typical for these types of sites.

Opinion 2. The mitigation response to the chemical impacts identified at the site was reasonable and typical.

Site soil background, site specific conditions, and the available data indicate otherwise. Therefore, I believe that her opinions are not based on sound science or a thorough review of the available site information. Additional details are presented below.

2.2 Opinion 1. Sites where soil and groundwater are affected by petroleum hydrocarbons and metals are common, and the Balloon Track is typical for these types of sites.

The Balloon Track Site is not "typical of the thousands of petroleum sites in California" for a number of reasons:

1. The site is located adjacent (within 250 ft) to Humboldt Bay and a tidally influenced slough runs through the property. The Bay is on the list of impaired water bodies due to PCBs and, based on evidence of bioaccumulation in Bay fish and shellfish, the listing was recently amended to include impairment from dioxins and furans. PCBs, dioxins, and furans are present at the site and are chemicals of concern for this site. The Bay is a major fishing resource and has been for thousands of years. This fact alone makes this a very unique site.

2. In addition to the storage of hydrocarbons on the site numerous other activities have occurred at the site as mentioned in Section 3.0 of RAM (2008). These activities are expected to result in a number of other chemicals of potential concern including but not limited to dioxins, furans, and PCBs. Use and storage of railroad ties, use of herbicides, past and present handling and disposal of wastes has resulted in chemicals of concern very different from a hydrocarbon site. In fact, consideration of this site as a typical hydrocarbons site would result in significant under-estimation of human health and ecological risks. Thus, the mix of contaminants present at the site is not typical.

3. The site has surface water bodies, fresh water wetland type habitats, and a slough with estuarine habitats that directly discharges to the Bay. This is not typical of a hydrocarbons site.

4. No analysis has been performed to estimate site-specific background metals concentrations, several of which exceed soil and groundwater screening levels. See, Tables 3 and 5 of RAM (2008). Further, similar to dioxins, furans and PCBs, metals tend to bioaccumulate and biomagnify in terrestrial and aquatic environment more than hydrocarbons. In fact, fish tissue samples from Clark Slough show this to be the case. Therefore, these metals may be of particular concern at this site.

Based on the above it is my opinion that the Baloon Track site is not a typical hydrocarbon site.

2.3 Opinion 2. The mitigation response to the chemical impacts identified at the site was reasonable and typical.

Table 3 – Percentage Occurrence of Arsenic, Zinc, and Copper in Groundwater (attached) shows that arsenic, zinc, and copper have been detected in almost all of the Site's groundwater monitoring wells. Therefore, Ms. Gallardo's statement that *"the relative absence of metals in groundwater from monitoring well samples at the Balloon Track site; a significant plume of metals-impacted groundwater resulting from historical site operations does not exist."* is incorrect. Insufficient effort has been made to delineate the metal impacts in groundwater. In addition, COCs including arsenic, PCBs, furans and dioxins still exist on the site at concentrations above the screening level, the residual chemicals continue to discharge to Clark Slough, and the site has not been adequately characterized.

Fish tissue samples collected from Clark Slough by HT Harvey and Associates on January 10, 2008 were analyzed for dioxins and furans. (I have been informed they are also being analyzed for PCBs.) The analytical lab results confirm that dioxins and furans are accumulating in the food chain in Clark Slough. Two species of Sculpin were analyzed. A sample of Staghorn sculpin (*Leptocottus armatus*) was found to have a dioxins/furans TEQ level of 4.288 pg/g (ppt). A sample of Prickly sculpin (*Cottus asper*) was found to have a dioxins/furans TEQ level of 2.635 pg/g (ppt). Both of these samples exceed relevant human health screening levels. For example, the United States Environmental Protection Agency recommends "no consumption" of fish tissue with dioxins/furans TEQ concentrations of 1.2 pg/g or greater. The USEPA notes that dioxins and furans are associated with a wide array of adverse health effects in experimental animals, including toxic effects to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system. Dioxins are also classified by the USEPA as probable human carcinogens. If dioxin-like PCBs are also present in these fish tissues, that would increase the TEQ and cumulative risk from these chemicals. Clark Slough is habitat for additional edible species of fish and shellfish such as dungeness crab and starry flounder. Species in higher trophic levels that feed on biota from Clark Slough, including predatory fish that might be consumed by humans, would be expected to have even higher levels of dioxins/furans.

The evidence of bioaccumulation of these highly toxic chemicals in Clark Slough, in combination with the evidence of continuing soil and sediment contamination, indicates that the limited soil removal actions at the site to date have not removed the significant threat to human health. It should also be noted that the USEPA, at the suggestion of the SWRCB, has recently listed Humboldt Bay as "impaired" for dioxins based on evidence of bioaccumulation in the food chain.

Based on the above considerations, it is my opinion that the mitigation response has been inadequate, that an imminent and substantial threat to human health exists at the site, and that additional risk management steps are necessary.

Agency for Toxic Substances Disease Registry (ATSDR), 1998. Toxicological Profile for Chlorinated Dibenzo-p-dioxins.

California State Water Resources Control Board (SWRCB), February 5, 2007. Geomatrix White Paper: 2006 Humboldt Bay Clean Water Act Section 303(d) Listing for Dioxins, letter to Mr. Mark Pawlicki of Sierra Pacific Industries from Mr. Thomas Howard, SWRCB.

California Environmental Protection Agency (CAL EPA), January 2005. Use of California Human Health Screening Levels in Evaluation of Contaminated Properties.

Geomatrix Consultants, Inc. (Geomatrix), June 16, 1997. Health Risk Assessment Report.

Geomatrix, April 24, 2000. Health Risk Assessment Addendum.

Geomatrix, December 14, 2001. Interim Remedial Action Plan.

Geomatrix, September 27, 2002. Soil Removal Report.

Geomatrix, December 19, 2003. Additional Soil Removal, Confirmation Soil Sampling, and Destruction of Piezometer P-9A Report.

Geomatrix, September 8, 2004. Scoping Ecological and Off-Site Human Health Risk Assessment, Sierra Pacific Industries, Arcata Division Sawmill, Arcata, California.

Geomatrix, January 28, 2008. Expert Report of James W. Embree, Ph.D., DABT.

Geomatrix, January 29, 2008. Expert Witness Report of Susan M. Gallardo, PE.

International Agency for Research on Cancer (IARC), 1997. http://monographs.iarc.fr/ENG/Monographs/vol69/volume69.pdf.

Risk Assessment and Management Group, Inc. (RAM), January 2008. Preliminary Human Health Risk Assessment Former Railroad Yard in City of Eureka, Humboldt County, California.

Site Photos, Dated from 1989, 1995, 2007, 2008

Test America, February 14, 2008. Project Number: G8A230302, Fish Tissue Sample Lab Results.

United States Environmental Protection Agency (USEPA), September 1999. Fact Sheet: Polychlorinated Dibenzo-p-Dioxins and Related Compounds Update: Impact on Fish Advisories.

USEPA, 2004, Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-***p*** Dioxin (TCDD) and Related Compounds National Academy Sciences (NAS) Review Draft.

USEPA Region 9, October 2004. Preliminary Remediation Goals Tables.

USEPA Region 9, November 30, 2006. Partial Approval Letter and Enclosure for California's 2004-2006 303(d) List letter from Ms. Alexis Straus to Mr. Thomas Howard, SWRCB.

Table 1
Changes in Risk due to Updated Toxicity Values of Non-Carcinogenic Chemicals
Humboldt Baykeeper

COC	Construction Worker						
	Geomatrix RA (2000) *			Updated			Ratio
	RfD_i	RfD_o	HI	RfD_i	RfD_o	HI	
Antimony [1]	0.0004	0.0004	2.0E-02	-	0.0004	1.54E-02	0.77
Arsenic [1]	0.0003	0.0003	3.0E-01	0.00000857	0.0003	7.92E-01	2.64
Barium [1]	0.00014	0.07	8.0E-02	0.00014 [6]	0.07 [6]	8.38E-02	1.05
Beryllium [1]	0.0000057	0.002	7.0E-03	0.000002	0.002	1.77E-02	2.53
Cadmium [1]	0.0005	0.0005	4.0E-03	0.00000571	0.0005	1.66E-02	4.15
Chromium, Total [1]	1.5	1.5	7.0E-05	-	1.5	7.08E-01	10120
Cobalt [1]	0.06	0.06	4.0E-04	0.00000057	0.02	1.66E+00	4154
Copper [1]	0.037	0.037	2.0E-02	-	0.04	1.61E-02	0.80
Lead [1]	-	-	NA	-	-	NA	NA
Mercury [1]	0.0003	0.0003	1.0E-03	0.000026	0.0003	1.58E-03	1.58
Molybdenum [1]	0.005	0.005	1.0E-03	-	0.005	1.04E-03	1.04
Nickel [1]	0.02	0.02	6.0E-03	-	0.02	6.05E-03	1.01
Selenium [1]	0.005	0.005	2.0E-04	0.00571	0.005	2.15E-04	1.08
Silver [1]	0.005	0.005	3.0E-04	-	0.005	2.47E-04	0.82
Thallium [1]	0.00008	0.00008	4.0E-02	-	0.000066	4.49E-02	1.12
Vanadium [1]	0.007	0.007	1.2E-02	-	0.007	1.20E-02	1.00
Zinc [1]	0.3	0.3	2.0E-03	-	0.3	1.48E-03	0.74
Acenaphthene [2]	0.06	0.06	9.0E-07	0.06 [6]	0.06 [6]	9.00E-07	1.00
Acenaphthylene [3]	0.06	0.06	4.0E-05	0.06 [6]	0.06 [6]	4.00E-05	1.00
Anthracene [2]	0.3	0.3	5.0E-07	0.3 [6]	0.3 [6]	5.00E-07	1.00
Benzo(g,h,i)perylene [4]	0.03	0.03	5.0E-06	0.03 [6]	0.03 [6]	5.00E-06	1.00
Fluoranthene [2]	0.04	0.04	9.0E-06	0.04 [6]	0.04 [6]	9.00E-06	1.00
Fluorene [2]	0.04	0.04	4.0E-06	0.04 [6]	0.04 [6]	4.00E-06	1.00
2-Methylnaphthalene [7]	0.00086	0.02	4.0E-04	0.00257	0.02 [6]	5.69E-06	0.01
Naphthalene [1]	0.00086	0.02	2.0E-03	0.00257	0.02 [6]	1.53E-03	0.77
Phenanthrene [5]	0.3	0.3	2.0E-06	0.3 [6]	0.3 [6]	2.00E-06	1.00
Pyrene [2]	0.03	0.03	9.0E-06	0.03 [6]	0.03 [6]	9.00E-06	1.00
Cumulative HI			**5.E-01**			**3.38E+00**	

Notes:
HI - Hazard Index
* - Addendum to Human Health Risk Assessment June 1997
RfD - Reference dose in mg/kg-d $_o$ - Oral, $_i$ - Inhalation NA - Not Available
[1] - Updated toxicity values from CHHSL Jan 2005
[2] - Updated toxicity values from EPA Region 9 PRG Table Oct 2004
[3] - Reference dose of acenaphthene used for acenaphthylene
[4] - Reference dose of pyrene used for benzo(g,h,i)perylene
[5] - Reference dose of anthracene used for phenanthrene
[6] - No updates in toxicity values.
[7] - Reference dose of naphthalene used for 2-methylnaphthalene
Ratio = Updated Risk/Geomatrix Risk

Table 2
Changes in Risk due to Updated Toxicity Values of Carcinogenic Chemicals
Humboldt Baykeeper

COC	Construction Worker						
	Geomatrix RA (2000) *			Updated			Ratio
	SF_o	SF_i	IELCR	SF_o	SF_i	IELCR	
Arsenic [1]	1.5	12	2.8E-06	9.45	12	1.4E-05	5.00
Beryllium	-	8.4	4.2E-09	-	8.4 [3]	4.2E-09	0.99
Cadmium [1]	-	15	1.6E-08	0.38	15	2.6E-08	1.61
Nickel	-	0.91	6.5E-08	-	0.91 [3]	6.5E-08	1.00
Naphthalene [1]	-	-	-	0.12	0.12	3.7E-10	NA
Benzo(a)anthracene [2]	1.2	0.39	5.7E-09	0.73	0.73	3.4E-09	0.60
Benzo(a)pyrene [2]	12	3.9	2.3E-08	7.3	7.3	1.4E-08	0.62
Benzo(b)flouranthene [2]	1.2	0.39	4.5E-09	0.73	0.73	2.8E-09	0.62
Benzo(k)flouranthene [2]	1.2	0.39	3.1E-09	0.073	0.073	1.9E-10	0.06
Chrysene [2]	0.12	0.039	5.1E-10	0.0073	0.0073	3.1E-11	0.06
Indeno(1,2,3-cd)pyrene [2]	1.2	0.39	2.2E-09	0.73	0.73	1.4E-09	0.62
Cumulative IELCR			**3.E-06**			**1.41E-05**	

Notes:
IELCR - Individual Excess Lifetime Cancer Risk
* - Addendum to Human Health Risk Assessment June 1997
[1] - Updated toxicity values from CHHSL Jan 2005
[2] - Updated toxicity values from EPA Region 9 PRG Table Oct 2004
[3] - Toxicity value not updated since 2000
SF - Slope factor in $(mg/kg\text{-}d)^{-1}$
$_o$ - Oral, $_i$ - Inhalation NA - Not Applicable
Ratio = Updated Risk/ Geomatrix Risk

Table 3
Percentage Occurrence of Arsenic, Zinc, and Copper in Groundwater
Humboldt Baykeeper

Wells	Arsenic			Zinc			Copper		
	Number of		% Detect	Number of		% Detect	Number of		% Detect
	S	D		S	D		S	D	
MW-1A	14	3	21.43	14	7	50.00	14	2	14.29
MW-2A	14	8	57.14	15	8	53.33	15	1	6.67
MW-3A	24	19	79.17	15	8	53.33	15	1	6.67
MW-4A	14	5	35.71	13	9	69.23	12	1	8.33
MW-5A	7	3	42.86	8	6	75.00	8	2	25.00
MW-6A	6	4	66.67	6	4	66.67	6	1	16.67
MW-7A	17	3	17.65	21	9	42.86	21	1	4.76
MW-10A	14	6	42.86	10	3	30.00	10	0	0.00
MW-11A	2	0	0.00	2	1	50.00	2	0	0.00
MW-12A	14	5	35.71	4	3	75.00	4	1	25.00
MW-P8A	27	16	59.26	8	6	75.00	8	1	12.50
MW-P9A	8	3	37.50	5	4	80.00	8	3	37.50
MW-1B	12	0	0.00	14	9	64.29	14	2	14.29
MW-2B	9	6	66.67	14	7	50.00	14	3	21.43
MW-3B	9	6	66.67	13	9	69.23	12	4	33.33
MW-11B	2	0	0.00	2	1	50.00	2	0	0.00
TOTAL	193	87	**45.08**	164	94	**57.32**	165	23	**13.94**

Notes:
S - Samples
D - Detects

APPENDIX A
CALCULATION OF RISK FOR ARSENIC IN FISH

APPENDIX A
CALCULATION OF RISK FOR ARSENIC IN FISH
HUMBOLDT BAYKEEPER

This appendix presents the calculation of risks for arsenic detected in fish. The risks have been calculated for both carcinogenic and non-carcinogenic adverse health effects for resident adult and child receptors consistent with guidance for ***Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties*** (CAL EPA 2005) and ***Risk Assessments Guidance for Superfund (RAGS) Volume I, Human Health Evaluation Manual (Part A)*** (USEPA 1989).

1.0 INPUT PARAMETERS

The calculation of risks requires the following input parameters:

(i) Exposure factors,
(ii) Toxicological properties,
(iii) Concentration of chemical in fish, and
(iv) Equations for calculation of risks.

Each of above input parameters is presented below.

1.1 Exposure Factors

Table A-1 presents the exposure factors for resident adult and child receptors. These exposure factors were obtained from RAGS (USEPA 1989).

1.2 Toxicological Properties

Table A-2 presents the toxicological properties of arsenic required to calculate the risks. Toxicological properties were obtained from ***Integrated Risk Information System (IRIS)*** (USEPA) and CHHSLs (CAL EPA 2005).

1.3 Concentration of Chemical in Fish

The average arsenic concentration of 0.29 mg/kg detected in the fish collected in January 2008 was used to calculate risks (refer Table A-3). Note the specific fish was young and the concentration in adult fish typically used for human consumption is expected to be higher. Further, concentrations in predator fish would be expected to be higher. The concentration used for the risk calculation is lower than the concentration of fish typically consumed by humans; therefore, the actual risk will be higher.

1.4 Equations

The equations used to calculate the carcinogenic and non-carcinogenic risks are presented below. These equations were obtained from RAGS Part A (USEPA 1989) based on the assumption that 100% of the fish is ingested from the slough or from other parts of the impacted bay.

1.4.1 Estimation of Carcinogenic Risk

Carcinogenic Risk is calculated as follows:

$$IELCR = \frac{C \times ED \times EF \times IR \times SF_o}{BW \times AT_c \times 365}$$

where,

IELCR	Risk or the increased chance of developing cancer over a lifetime due to exposure to a chemical [-],
C	Concentration of chemical in fish [mg/kg],
ED	Exposure duration [year],
EF	Exposure frequency [day/year],
IR	Fish ingestion rate from water body of concern [kg/day],
SF_o	Chemical-specific oral cancer slope or potency factor $[mg/(kg\text{-}day)]^{-1}$,
BW	Body weight [kg],
AT_c	Averaging time for carcinogens [year], and
365	Converts AT_c in years to days [day/year].

1.4.2 Estimation of Non-Carcinogenic Risk

Non-carcinogenic risk is estimated as:

$$HQ = \frac{C \times ED \times EF \times IR}{BW \times AT_{nc} \times 365 \times RfD_o}$$

where,

HQ	Hazard quotient for individual constituents [-],
C	Concentration of chemical in fish [mg/kg],
ED	Exposure duration [year],
EF	Exposure frequency [day/year],
IR	Fish ingestion rate from water body of concern [kg/day],
BW	Body weight [kg],
AT_{nc}	Averaging time for non-carcinogens [year],
365	Converts ATnc in years to days [day/year], and
RfD_o	Chemical-specific oral reference dose [mg/kg-day].

2.0 RESULTS

Table A-4 presents the risks for the resident adult and child receptors for arsenic. The carcinogenic risks for adult and child are 1.1×10^{-4} and 1.5×10^{-4}, respectively, which significantly exceed the acceptable target risk level of 1×10^{-6}. The presence of other chemicals in the fish would increase the risk further.

3.0 REFERENCES

California Environmental Protection Agency (CAL EPA), January 2005. Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties.

USEPA, Integrated Risk Information System (IRIS). http://www.epa.gov/iriswebp/iris/.

USEPA, December 1989. Risk Assessments Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A).

Table A-1
Exposure Factors for Adult and Child
Humboldt Baykeeper

Parameter	Symbol	Unit	Value Used for Adult	Value Used for Child
Averaging Time for Carcinogen	AT_c	year	70	70
Averaging Time for Non-Carcinogen	AT_{nc}	year	=ED	=ED
Body Weight	BW	kg	70	15
Exposure Duration	ED	year	30	9
Exposure Frequency	EF	day/year	365	365
Ingestion Rate (daily)	IR	kg/day	0.0065	0.0065

Table A-2
Toxicological Properties
Humboldt Baykeeper

Chemical	Oral Ingestion Slope Factor (SF_o)	Oral Ingestion Reference Dose (RfD_o)
	$(mg/kg\text{-}day)^{-1}$	(mg/kg-day)
Arsenic	9.450	0.0003

Table A-3
Fish Data Collected January 10, 2008
Humboldt Baykeeper

Parameter	Sample 1		Sample 4	
Dioxins / Furans*	**Concentration**	**TEQ Concentration**	**Concentration**	**TEQ Concentration**
2,3,7,8-TCDD	**0.47**	**0.470**	**0.41**	**0.410**
Total TCDD	**0.68**		**0.54**	
1,2,3,7,8-PeCDD	**2.00**	**2.000**	**1.3**	**1.300**
Total PeCDD	**2.8**		**1.3**	
1,2,3,4,7,8-HxCDD	**0.95 J**	**0.095**	**0.40 J JA**	**0.040**
1,2,3,6,7,8-HxCDD	**4.2**	**0.420**	**2.1**	**0.210**
1,2,3,7,8,9-HxCDD	**1.4**	**0.140**	**0.66 J**	**0.066**
Total HxCCD	**29**		**8.6**	
1,2,3,4,6,7,8-HpCDD	**73**	**0.730**	**35**	**0.350**
Total HpCDD	**160**		**59**	
OCDD	**310**	**0.093**	**120**	**0.036**
2,3,7,8-TCDF	**0.17 CON J**	**0.017**	**0.28 CON J J**	**0.028**
Total-TCDF	**0.77**		**0.95**	
1,2,3,7,8-PeCDF	**0.24 J JA**	**0.007**	**0.24 J JA**	**0.007**
2,3,4,7,8,-PeCDF	**0.42 J**	**0.130**	**0.23 J**	**0.069**
Total PeCDF	**1.8**		**1.1**	
1,2,3,4,7,8-HxCDF	**0.59 J**	**0.059**	**0.33 J JA**	**0.033**
1,2,3,6,7,8-HxCDF	**0.80 J JA**	**0.080**	**0.62 J**	**0.062**
2,3,4,6,7,8-HxCDF	**0.25 J**	**0.025**	**0.15 J**	**0.015**
1,2,3,7,8,9-HxCDF	<0.075	0	<0.045	0
Total HxCDF	**3.0**		**2.8**	
1,2,3,4,6,7,8-HpCDF	**2.0 JA**	**0.020**	**0.82 J JA**	**0.008**
1,2,3,4,7,8,9-HpCDF	<0.47	0	<0.55	0
Total HpCDF	**4.8**		**1.6**	
OCDF	**4.3**	**0.001**	**2.5**	**0.001**
Others				
Arsenic **	0.24		0.34	
Copper **	1.6		1.3	
Percent Lipids	3.5		3.4	

Notes:
** All dioxins & furans data in and of pg/g. (Analysis Method SW846 8290).*
***Arsenic & Copper in mg/kg. (Analysis Method SW846 6020).*
% Lipids (Analysis Method SW846 8290).
E Estimated result. Result concentration exceeds the calibration range.
CON Confirmation analysis
J Estimated result. Result is less than the reporting limit.

Sample 1 - Leptocottus armatus
Sample 4 - Cottus asper
Note: Samples 2 & 3 were not analyzed

Table A-4
Calculated Risk for Ingestion of Fish by Adult and Child
Humboldt Baykeeper

Chemical of Concern	Adult		Child		Maximum	
	IELCR	HQ	IELCR	HQ	IELCR	HQ
Arsenic*	1.09E-04	8.98E-02	1.53E-04	4.19E-01	1.53E-04	4.19E-01

Notes:
*: Risk calculated using average concentration from Table 3
IELCR: Individual excess lifetime cancer risk
HQ: Hazard quotient